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A Neurofeedback Intervention Program to Improve the Mental Well-Being of Teachers

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Abstract

Educational interventions proposed so far in the field of mental well-being in education mostly address students. This study focused on teachers and investigated whether neurofeedback (NF) training can increase optimism, self-esteem, life satisfaction, and the ability to cope with stressful events, reflecting on the research literature that emphasizes these four factors, which affect the ability to be confident in dealing with uncertainty and distress. Forty teachers aged 35 - 55 participated in the study. The test group took part in 12 NF training sessions, and the control group was not treated. Our findings indicate that compared to the control group, measures of optimism, self-esteem, life satisfaction, and coping with stressful events improved significantly in the test group. This is a pioneer attempt to test a mental welfare intervention program for teachers through NF. This study calls for the development of teacher intervention programs using physiological measurement and technological innovations to improve their mental health and allow them to cope better with stressful teaching conditions.

Keywords

Mental Well-Being, Neurofeedback, School Teachers, Optimism, Self-Esteem, Stress

1. Introduction

Teachers' satisfaction, stress and burnout have been the focus of many studies for years. Teachers' challenges and difficulties in the new "normal educational environment" following the COVID-19 pandemic triggered more stress, burnout, and emotional exhaustion [1] [2]. Recent studies have investigated teachers' characteristics of positive mental health, namely optimism, and its correlation with satisfaction, stress, and burnout. Studies reported that teachers' optimism correlates with less perceived workload [3] and may affect both their well-being and their levels of productivity and performance [4].

Teachers' positive mental health is an important variable that adversely affects students' achievements and significantly improves professional outcomes, such as induced feelings of stress and burnout. Therefore, we addressed optimism, self-esteem, life satisfaction, and the ability to cope with stressful situations since studies indicate that they are among the main psychological assets that directly and indirectly affect stress and emotional exhaustion, resulting in better persistence, confidence when facing uncertainties, hence less vulnerable to distress [5]-[7].

Studies tested educational environments designed to encourage mental well-being [8]. However, to the best of our knowledge, just a few studies investigated interventions that aimed to develop well-being assets among teachers through an internal psychological procedure [9].

Also, it seems that no intervention has yet been suggested to use Brain-Computer-Interfaces (BCI) for this purpose. Thus, we developed this intervention to study whether teachers' optimism, ability to cope with stressful situations, life satisfaction, and self-esteem could be improved by a neurofeedback brain training protocol.

2. Neurofeedback: Brain Training

Neurofeedback (NF), also termed electroencephalogram (EEG) biofeedback, combines psychology, technology, and neuroscience. Neurofeedback trains the person to control his/her brain. Its contemporary goals include clinical (e.g., ADHD, obsessive-compulsive disorder - OCD, anxiety, depression) and non-clinical (e.g., peak performance) applications. Studies found that several sessions of the neurofeedback brain training protocol improved functional state and enhanced everyday life performance [10].

Neurofeedback is a gradual learning process aiming to regulate patterns of brain activity. Computer software and electrodes placed on the trainee's scalp and analysis of the trainee's electrical signals allows for real-time watching of the activity wave in the trainee's brain on the computer screen. The software's feedback is presented to the trainee according to the set targets, in audio-visual form, and "teaches" the trainee how to regulate his brain patterns through the repetition of immediate feedback on particular brain activity [11].

Our study did not address the clinical state but followed the trend of neurofeedback applications with healthy participants, commonly called the 'peak performance' field [12]. Previous studies indicated that NF enables better coping with stressful situations and improves concentration and memory capabilities [13]. Specific advantages of NF training over other treatment options (e.g., medication) were found, including its non-invasive intervention process and the endurance of the effects that are evidentially stable for years after the end of the training period [11].

2.1. Neurofeedback Protocols

This study employed a commonly used neurofeedback procedure: frequency/power training protocols. These protocols typically use surface EEG electrodes to provide real-time feedback designed to increase or decrease the amplitude (or power) of selected frequency bands at specific scalp locations. The protocol is defined primarily by two parameters: electrode placement, selected in relation to the neural process or behavioral outcome targeted for training, and the frequency band(s) to be reinforced and/or inhibited [14].

EEG activity is recorded from multiple scalp regions—including frontal, temporal, parietal, central, and occipital sites—and is conventionally decomposed into frequency bands such as theta, alpha, and beta. Neurofeedback protocols therefore vary not only in the EEG band targeted for reinforcement or inhibition, but also in electrode placement; both parameters should be selected in relation to the intended functional outcome.

Importantly, the same clinical or psychological goal may be approached through more than one protocol configuration. For example, anxiety reduction may involve enhancing alpha activity over parietal sites or inhibiting excessive high-beta activity at right temporal sites [14]. The following sections outline these two core dimensions of frequency/power neurofeedback protocols: targeted frequency bands and electrode location.

2.2. Brainwave Frequency

EEG activity is commonly described in terms of frequency bands: delta (below 4 Hz), theta (4 - 8 Hz), alpha (8 - 13 Hz), beta (13 - 30 Hz), and gamma (above 30 Hz). These bands are associated with broad patterns of arousal and cognitive functioning rather than with fixed, one-to-one psychological states. In general, delta activity predominates during deep sleep; theta activity is often observed during drowsiness and internally focused states; alpha activity is characteristic of relaxed wakefulness; The beta range may be subdivided into lower-frequency beta (beta1 or sensorimotor rhythm SMR; approximately 12 - 15 Hz), mid-beta activity (beta2; approximately 15 - 20 Hz), and high-beta activity (beta3; approximately 20 - 30 Hz). SMR is commonly associated with a state of calm, stable alertness, whereas mid-beta activity is generally linked to active cognitive engagement and focused attention. High-beta activity may reflect heightened arousal; when excessive or persistent, it has been associated with tension, hypervigilance, and anxiety-related states.

Frequency/power neurofeedback protocols can be designed either to reinforce a targeted EEG band or to inhibit activity within a selected band. Broadly, lower-frequency protocols—particularly alpha or alpha/theta training—are often used when the intended outcome is relaxation or reduced arousal. By contrast, protocols that reinforce high frequencies (beta1, 2) are generally intended to support alertness, sustained attention, and cognitive control [15]. waves. Commonly used approaches include alpha training, beta or SMR training, theta/beta-ratio training, and alpha/theta training.

Among the anti-stress protocols, beta2 and the eyes closed Alpha/Theta (A/T training) protocols have been used for a long time for relaxation and mood improvement purposes for optimal performance effects in healthy participants. Alpha oscillations (8 - 12 Hz) correspond to a state of resting wakefulness among healthy individuals [16]. Studies indicate that the Alpha protocol generates a calm and pleasant situation of creative activity and relaxation. Studies of alpha/theta neurofeedback have reported changes in self-reported mood and personality-related outcomes, expressed in being more warm-hearted, emotionally stable, relaxed, and satisfied, as well as feeling better about themselves after training [17]. Moreover, when relaxing-target training sessions were combined with theta (4 - 8 Hz) and high-beta (22 - 37 Hz) inhibitors, results indicated reduced anxiety [12].

Recent NF protocols developed from contemporary neuroscience include upper-alpha training (10 - 13 Hz) using the eyes-open protocol. Some experimental findings support upper-alpha as a promising NF parameter correlated to "evoking emotions" that is worth further investigation, whereas theta/alpha, theta/beta1, or theta/beta2 feedback is already established in therapy [18] [19]. As explained herein, our study used the upper alpha protocol combined with theta and high-beta inhibitors.

2.3. Brain Sites

EEG electrodes record electrical activity at the scalp and provide an indirect measure of the summed neural activity, correlating with the corresponding cerebral cortical areas [14]. Electrode placement is conventionally standardized using the international 10-20 system. In this nomenclature, letters identify the general cortical region (e.g., F = frontal, T = temporal, C = central, P = parietal), while odd and even numbers indicate left- and right-hemisphere positions, respectively; for example, F3 denotes a left frontal site and C4 a right central site.

Several brain regions have been linked to socio-emotional processing, particularly the amygdala and orbital portions of the prefrontal cortex. An understudied region is the temporal pole [20]. This region is highly interconnected with the amygdala and orbital frontal cortex. Researchers refer to it as the paralimbic region. It is involved in the sensory and limbic processing of emotional states [16] and is considered necessary for emotional processing and regulation.

The right temporal region has been implicated in aspects of affective processing and socially relevant memory that is associated with mood changes and seems to be the site of recollection of episodic personal memories. In contrast, the left temporal regions are more often associated with semantic memory. In a study of neurofeedback for PTSD, the right temporal site (T4 by the 10 - 20 placement method) training exhibited more significant decreases in PTSD symptoms than the left temporal (T3) placement [21]. Ribas et al. [22] identified a pattern related to high beta waves, indicating stressfulness - more elevated in the right temporal lobe (T4) than in the left temporal lobe (T3), associated with the activation of the amygdalae and the hypothalamus to warn of danger.

3. Psychological Assets and Their Related NF Protocols

In this study, we investigated optimism, self-esteem, life satisfaction, and coping with stressful situations since they directly and indirectly, affect one's persistence and confidence in facing uncertainties and distress. Some recent studies point to their relation to brain activity.

3.1. Optimism

Studies found that optimism serves an adaptive function, enhancing proactive behaviors while diminishing stress and anxiety [23] [24]. When the optimal state is balanced, reality-anchored optimism helps get the most out of opportunities [25]-[27].

In this study, we investigated whether right temporal lobe NF training would lead to increased optimism based on research that point to the correlation between right lobe function and brain training to levels of optimism [17] [28].

3.2. Self-Esteem

Self-esteem is the individual's perception of the self in a positive or negative attitude. Self-esteem is closely related to a person's basic life view (optimism or pessimism) and ability to cope with difficulties and challenges. A person with high self-esteem believes in his ability to influence his environment. Since his heightened sense of competence, he/she feels safe and valuable [29]. The pessimist tends to be self-critically insecure in facing life's challenges and feels less useful [30] [31].

Studies suggest that the sense of self manifests in the right temporal lobe. Studies [32] argue that avoidance behaviors characterize individuals with lower self-esteem and under activity, pessimism, and depression. Hence training the brain for this target would trigger its activation. Following a left > right asymmetry principle, this could be achieved by increasing the alpha levels and lowering the beta levels in the right temporal lobe [32] [33].

We thus hypothesized that neurofeedback up-training alpha and down-training high beta in the right temporal lobe would correlate positively with self-esteem.

3.3. Ability to Cope with Stressful Situations

Individuals with high levels of optimism tend to report low levels of psychological stress [34] and can cope better with stressors and crises [35]. We investigated whether uptraining alpha would lead to better coping with stressful situations based on findings showing that alpha is associated with alert relaxation and reduced anxiety in healthy participants [12] [14].

3.4. Life Satisfaction

Whereas affect measures reflect short-term reports of subjective well-being and show situational variability, life satisfaction relates to relatively stable, long-term subjective well-being judgments [36]. Studies linked higher life satisfaction to higher self-esteem, better physical and psychological health, fewer stressful life events, and less negative affect [36].

Kong *et al*. [36] investigated the structural neural correlates of life satisfaction and found that life satisfaction correlates with the regional gray matter volume in the right cortex. Several studies have shown statistical improvements in quality of life, including life satisfaction, following NF alpha-theta training [37] [38]. Therefore, we assumed that right-side alpha training would improve life satisfaction.

4. Method

4.1. Participants

The participants were recruited through social networks as a convenient sample of teachers. We invited primary-school teachers without clinical backgrounds in anxiety or depression to participate in the research and explained the method.

Sixty-seven males and females approved the consent form. Initially, 36 teachers were randomly assigned to participate in the experimental group. Still, only 20 females participated in the statistical analysis (4 performed only in the first stage of pre-treatment measures, six left after the second session, four after the fifth session, and two after the sixth session). In the experimental group (n = 20), the participants were between 35 and 48 years (M = 41.20, SD = 4.70). Additional 20 female teachers were assigned to the control group (untreated), aged 35 - 45 years (M = 40.00, SD = 3.38).

4.2. Procedure

The control group received no intervention. The experimental group received 12 NF training sessions of 40 minutes each. An active electrode was placed at T4. Training targets aimed at increasing the upper alpha (10 - 13 Hz) and decreasing the upper theta (20 - 28 Hz). When the trainee's alpha wave increased and the high beta wave decreased, an animation was played on the screen. When the animation stopped, the participants could notice their brain waves were not meeting the targets. Each NF training session consisted of steps of 5 minutes animation programs, and after each step, the participants had a 2 minutes interval of rest to avoid fatigue.

4.3. Measurements

Participants filled out the following psychological questionnaires:

We measured subjective satisfaction with life by the Satisfaction With Life Scale (SWLS) [39]. It consists of 5 items (e.g., "I am satisfied with my life"; "If I could live my life over, I would change almost nothing"), rated on a 7-point Likert-type scale (α Cronbach = 0.90).

We measured optimism by the Life Orientation Test (LOT) [40], which includes 12 items (e.g., "I always see the good side of things"; "I hardly expect things to work out in my favor"), rated on a 5-point Likert-type scale (α Cronbach =

0.78).

We measured self-esteem by the Rosenberg Self Esteem Scale (RSES) [41], which consists of 12 items (e.g., "I can do things as well as most other people"; "I take a positive attitude toward myself"), rated on a 7-point Likert-type scale (α = 0.86).

We measured the ability to cope with stressful situations using The Connor Davidson Resilience Scale questionnaire (CD-RISC) [42]. It includes 25 items on a 5-point Likert-type scale (e.g., "I consider myself a strong person"; "Under stressful situations, I focus and think clearly") (α = 0.0.91).

5. Results

The means and SD of the research variables were calculated for each group in the two-time measures (**Table 1**).

Table 1. Means and standard deviation of research variables for each group in both time measurements.

	Experiment group		Control group	
Variable	T1 Mean (SD)	T2 Mean (SD)	T1 Mean (SD)	T2 Mean (SD)
Optimism	20.60 (0.43)	20.87 (0.43)	30.17 (0.41)	20.96 (0.41)
Life satisfaction	40.85 (0.87)	50.03 (1.13)	50.53 (0.64)	50.00 (1.00)
Self-esteem	40.25 (0.91)	40.49 (1.00)	40.45 (0.84)	40.47 (0.88)
Resilience factors	30.66 (0.53)	30.84 (0.48)	30.85 (0.41)	30.78 (0.46)

We performed *T-tests* for independent groups to investigate whether there were differences at time points: T1 (before training), T2 (after training), and the control group. The only significant difference was that the control group reported higher optimism levels than the experimental group.

We then performed four Two-Way Mixed ANOVA analyses with each "group" (experimental, control) to compare variables and time points at T1 (before training) and T2 (after training) within variables. We tested whether the level of optimism, life satisfaction, self-esteem, and coping skills increased after NF training. The results indicated that:

Optimism: We found a significant main effect in Time ($F(1,37) = 46.64$, $p < 0.001$, $\acute{\eta}_p^2 = 0.56$), but not in Group ($F(1,37) = .058$, p = n.s, $\acute{\eta}_p^2 = 0.002$). However, we revealed an interaction ($F(1,37) = 24.18$, $p < 0.001$, $\acute{\eta}_p^2 = 0.39$) that indicated increased levels of teachers' optimism in the experimental group over time. In contrast, there were no significant differences in the control group between the time measurements.

Life satisfaction: We found a significant main effect in Time ($F(1,38) = 24.55$, $p < 0.001$, $\acute{\eta}_p^2 = 0.39$), but not in Group ($F(1,38) = 0.36$, p = n.s, $\acute{\eta}_p^2 = 0.01$). However, we revealed a significant interaction ($F(1,38) = 29.28$, $p < 0.001$, $\acute{\eta}_p^2 = 0.43$)

over time in increased levels of teachers' life satisfaction in the experimental group, whereas there were no significant differences in the control group between time measurements.

Self-esteem: We did not find a significant main effect in Time ($F(1,38) = 2.74$, $p = 0.11$, $\eta_p^2 = 0.07$) or group ($F(1,38) = 0.21$, $p =$ n.s, $\eta_p^2 = 0.006$). However, we found a close to significant interaction ($F(1,38) = 3.68$, $p = 0.06$, $\eta_p^2 = 0.09$), which indicated increased levels of teachers' self-esteem in the experimental group over time. In contrast, there were no significant differences in the control group between time measurements.

The *ability to cope with stressful situations:* We found a close to significant main effect for Time ($F(1,38) = 3.05$, $p = 0.08$, $\eta_p^2 = 0.07$), but not in the group ($F(1,38) = 0.17$, $p =$ n.s, $\eta_p^2 = 0.005$). However, significant interaction ($F(1,38) = 10.71$, $p = 0.002$, $\eta_p^2 = 0.22$) indicated increased teachers' ability to cope with stressful situations in the experimental group over time. In contrast, there were no significant differences in the control group between time measurements.

The four Two-Way Mixed ANOVA analyses confirmed that teachers' optimism, life satisfaction, self-esteem, and ability to cope with stressful situations increased after NF training. In contrast, the control group had no differences in these variables.

6. Discussion

Scholars have stressed that any school-based approach to promoting mental health should begin with teachers' mental health [43]. However, most of the interventions constantly proposed for mental health in school address students, and only a few address teachers' well-being.

In this study, we investigated a neurofeedback procedure on teachers under unusual stress, especially since the Covid-19 pandemic wake. Pidgeon [44] suggested the term "Corona wear" and examined the correlation between the pandemic and three other factors: resilience, social support, and optimism. Among them, only optimism has significantly predicted Corona-wear. Thus, he emphasized the importance of interventions to increase optimism and reduce the Corona-wear.

Following these recommendations, we tested an intervention program that uses neuroscience-based technology to improve the level of optimism, satisfaction in life, self-esteem, and the ability to deal with stressful situations among teachers. Similar intervention programs have been designed mainly to develop an awareness of similar factors and practical coping methods. In a recent meta-analysis of positive psychological interventions [45], the authors have found that these intervention programs generally have a low to medium effect on stress levels. Therefore, Russo [46] recommends the inclusion of technologies aiming to increase an individual's awareness of biological processes (e.g., brain waves, heart rate, muscle tension) to better assist in reducing adverse symptomatology and empowering positive ones.

In our study, we joined other recent studies that call for the use of technology for psychological interventions [47] [48]. Among studies that recommend this venue is van Agteren's [49] study that developed a software application to raise the sense of meaning, satisfaction with life, and positive emotion and found improvement in these measures. Such is Andersson's [50] study that investigated a Mindfulness-focused intervention for teachers using a software program. He found improvement in several health metrics following the intervention program. In his view, the advantages of technology in this kind of intervention are that it increases engagement and persistence and allows personalization.

Hepburn and his colleagues [51] also investigated a teachers' intervention program on well-being issues and stress. They emphasized that besides the interventions aimed at teachers as a group, it is also essential to design and test individually tailored interventions for teachers.

Thus, our research joins these efforts and contributes to these recommendations by testing a neurofeedback protocol. One should remember that neurofeedback protocols require extensive research to better adjust for different populations, cultures, and genders. The literature describes differences between groups by demographic variables, such as perseverance in the intervention program. As noted above, more female teachers agreed to participate in this study, and they may have initially agreed to participate in the long training sessions in our study since they suffer more from stress [44] or are more willing to persevere in neurofeedback treatment [52]. Although no gender differences were reported in NF treatment, some researchers recommend further investigating gender variables and the correlation with NF training [52].

Additionally, other aspects of using technology with teachers need to be studied. For example, neurofeedback devices are still expensive. Studies need to investigate their economic and time cost-effectiveness further. Fear of exposure to personal physical metrics cannot be ignored and needs further understanding.

We suggest considering these concerns and reservations in developing future NF interventions with teachers and students. Nonetheless, our research is a step toward implementing other physiological-based interventions, such as magnetic stimulation (TMS) [53]. It clarifies the potential and prospects of technology in such interventions. However, one should consider the concern and objections as regards invasive protocols.

The current research suggests using NF to improve mental well-being, reflecting on Przybylko's [48] call for a new NF paradigm of cross-cultural and universal interventions. Tabibnia [54] offered a model that distinguishes between three brain activity channels relevant to improving well-being:

a channel aimed at reducing negative emotions and stress responses from the amygdala and hypothalamus;

a channel aimed at strengthening positive emotions triggered by brain reinforcement and motivation mechanisms;

a channel aimed to improve self-transcendence through brain mechanisms that reduce rumination in brain areas considered to increase self-reflectivity.

She sought intervention programs compatible with each channel, including Computer Based Training - CBT, and social support. However, her review did not include neurofeedback. The reason may lie in the trendiness of neurofeedback in education that brings some to apply caution in applying neuroscience to education or psychology. Many still emphasize that when selecting a neurofeedback protocol for an educational setting, one should carefully examine the suitability of the protocol for specific purposes and populations.

7. Conclusions

To the best of our understanding, the contribution of our research is the conceptualization of optimism in an applied setting that suggests a unique protocol for NF training. We hope that a better understanding of the correlation between brainwave activity and its impact on various well-being factors will help us understand how they may assist in dealing with other stressors - not only in the educational system. We hope the NF training method will broaden ways to nurture psychological assets. We hope that future research will continue to examine this protocol for other psychological factors. We also hope that future longitudinal studies will follow our results and better assess the validity and impact of our findings.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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